

MICROWAVE ABSORPTION AND FREQUENCY SHIFT MODEL FOR DETERMINING DIELECTRIC CONSTANTS OF A SPHERE IN A RECTANGULAR CAVITY

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ABSTRACT

A microwave absorption and frequency shift model for a sphere in a rectangular cavity was experimentally verified. This theory calculates the electromagnetic fields throughout the cavity, including the interior of the sphere, in an approximation scheme based on Mie scattering formalism. Both the sample quality factor, Q , and the cavity resonance frequency shift, Δf , can be predicted given the sample size and dielectric properties, and cavity dimensions and excitation mode. Conversely by measuring Q and Δf , the dielectric parameters even for a relatively large spherical sample can be accurately determined. Measurements on a 1 cm diameter spherical Zerodur glass sample were performed at room temperature along the x axis in a rectangular cavity excited in the TM₃₃₀ mode at 5.05 GHz. This large sample is outside the range of validity of the small sphere approximation ($ka \ll 1$). This new approach transcends usual cavity perturbation techniques. Excitation and detection, loop couplers, weakly linked to the cavity, were used to excite and detect an isolated mode. The sample was supported by fine threads to minimize perturbations from the support. The measured spatial dependence of the absorption for the sample was inverted, i.e., minimum absorption occurred at the maximum empty cavity electric field position, contrary to expectations based on a small sphere approximation and ordinary cavity perturbation theory. This new model best fit parameters to the experimental spatial absorption and frequency shift data were $\epsilon' = 5.7 \pm 0.1$ and $\epsilon'' = 0.065 \pm 0.005$. These results will be compared to independent measurements of the dielectric constants of samples obtained from the same batch. [Work supported by NASA].